CFSv2 ensemble prediction of the wintertime Arctic Oscillation

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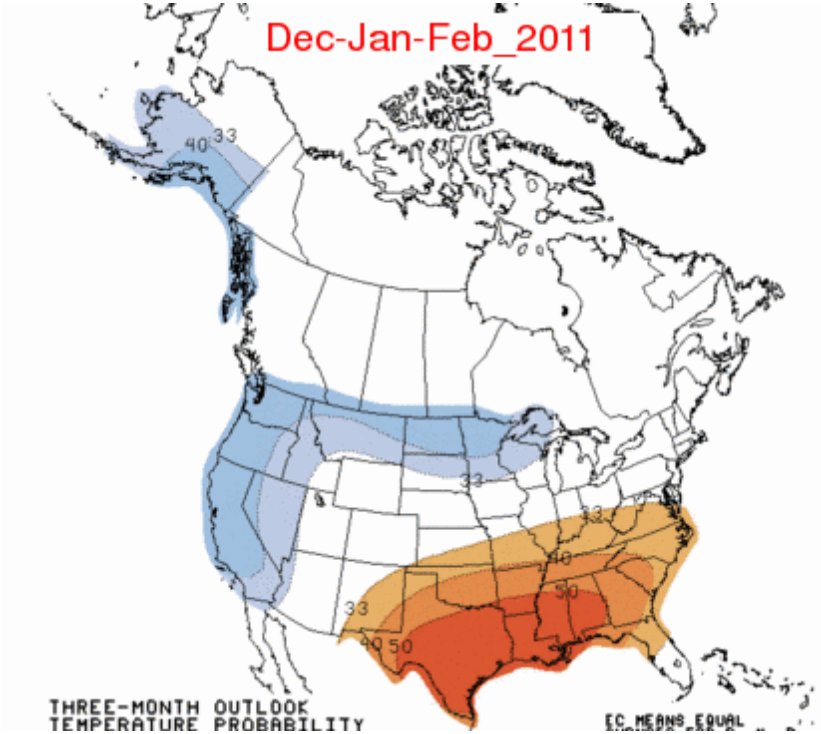
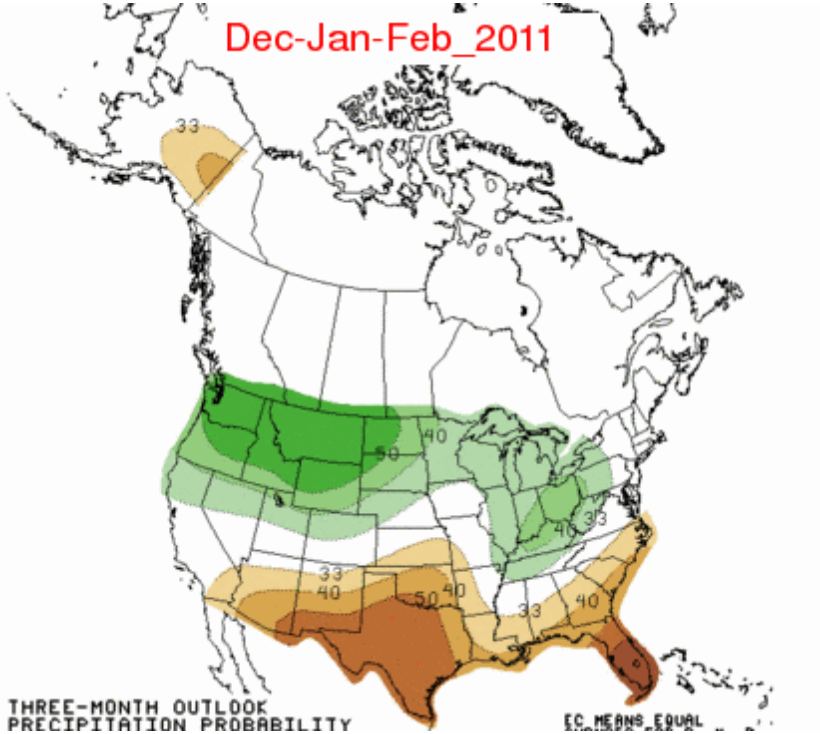
Motivation:

The Arctic Oscillation is often considered a "wildcard" for the CPC wintertime outlooks

How well does CFSv2 capture variability in the DJF AO index as a function of lead time and ensemble size?

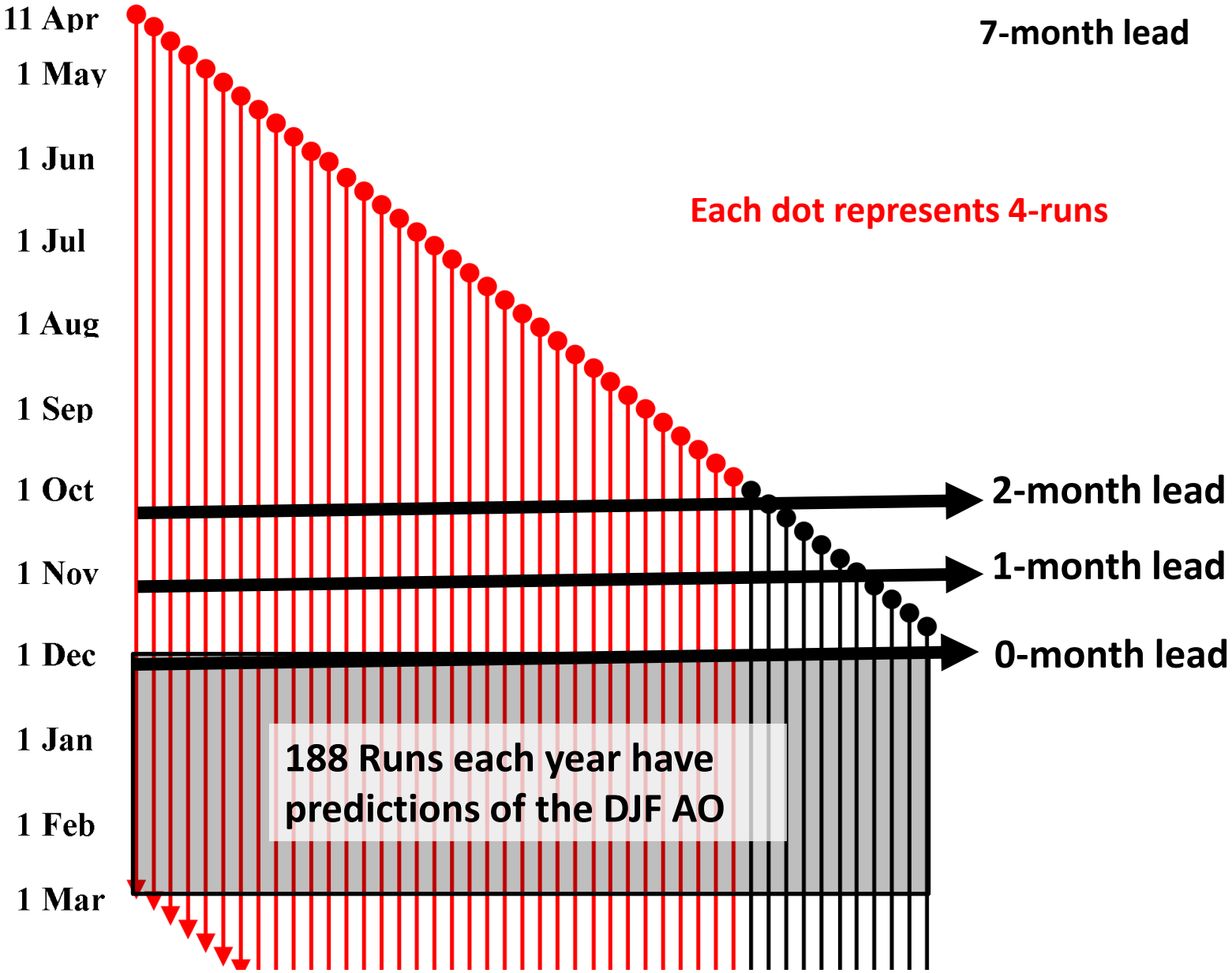




CFSv2 seasonal hindcasts

- Operational at CPC starting Spring 2011.
- 28-year seasonal hindcast record for DJF (the 1982/1983 season through the 2009/2010 season).
- Four runs are started every five days through out this period and run for 9 months.

Hindcast runs available for predicting the DJF AO



Hindcast runs available for predicting the DJF AO

	0-month lead	1-month lead	2-month lead	3-month lead	4-month lead	0-month lead	6-month lead
Date of forecast	Nov 30	Oct 31	Sep 30	Aug 31	Jul 31	Jun 30	May 31
Number of runs available	188	164	140	116	92	68	44
Range of model initialization dates	Apr 11 – Nov 27	Apr 11-Oct 28	Apr 11-Sep 28	Apr 11-Aug 29	Apr 11-Jul 30	Apr 11-Jun 30	Apr 11-May 31

Methodology

1) **Calculate hindcast DJF AO indices**. For each of 188 runs every year, we calculate the AO index as the projection of forecast DJF 1000 mb geopotential height anomaly onto the CFSR AO loading pattern. This results in a 28-year AO time series for each of the 188 runs. These time series are then all detrended and standardized.

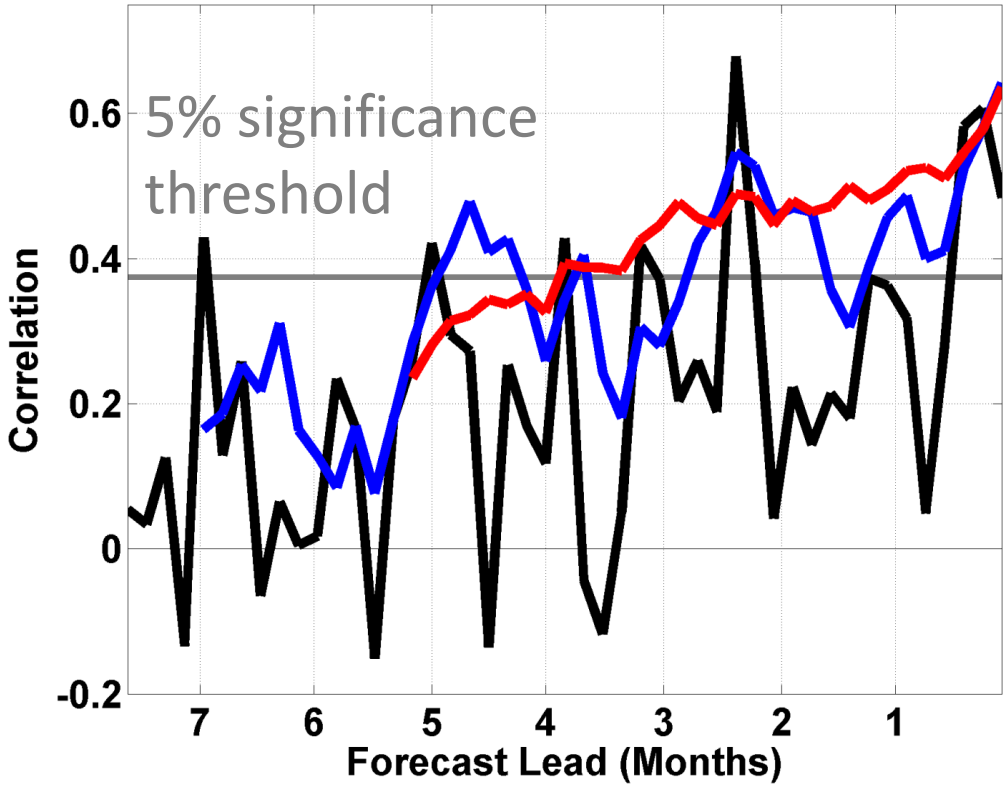
2) **Calculate the reference DJF AO index**: The 28-year observed AO index is calculated based on CFSR and is also detrended and standardized. Correlation with CPC official AO index is r=.995.

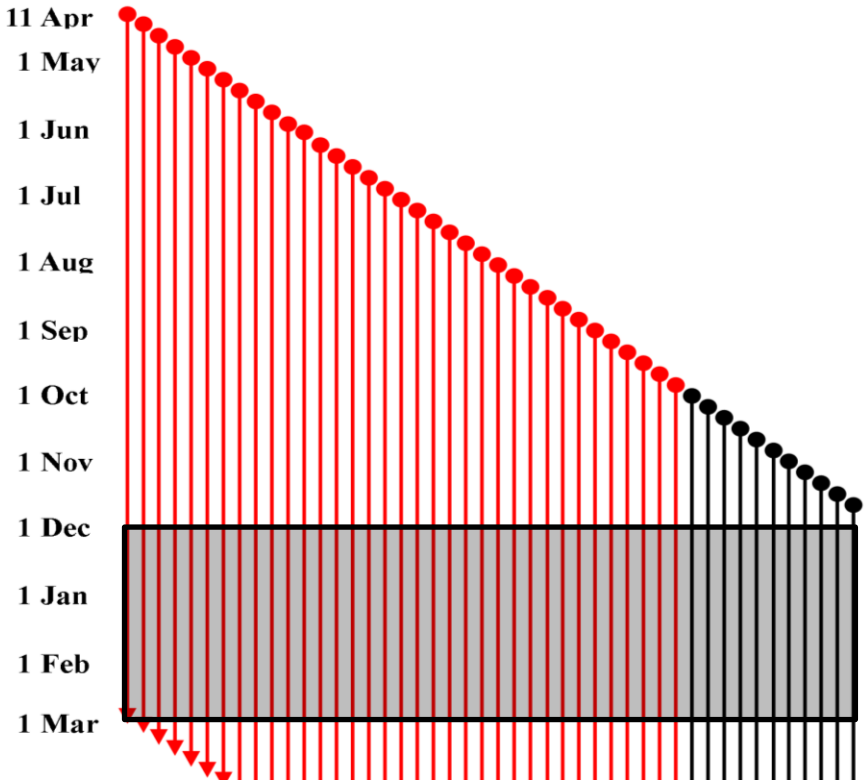
3) **Calculate ensemble-mean AO forecasts:** Ensemble mean AO indices are calculated from subsets of the 188 runs.

4) **Calculate anomaly correlation skill** between observations and the various ensemble means.

Skill of CFSv2 forecasts of the DJF AO as a function of forecast lead

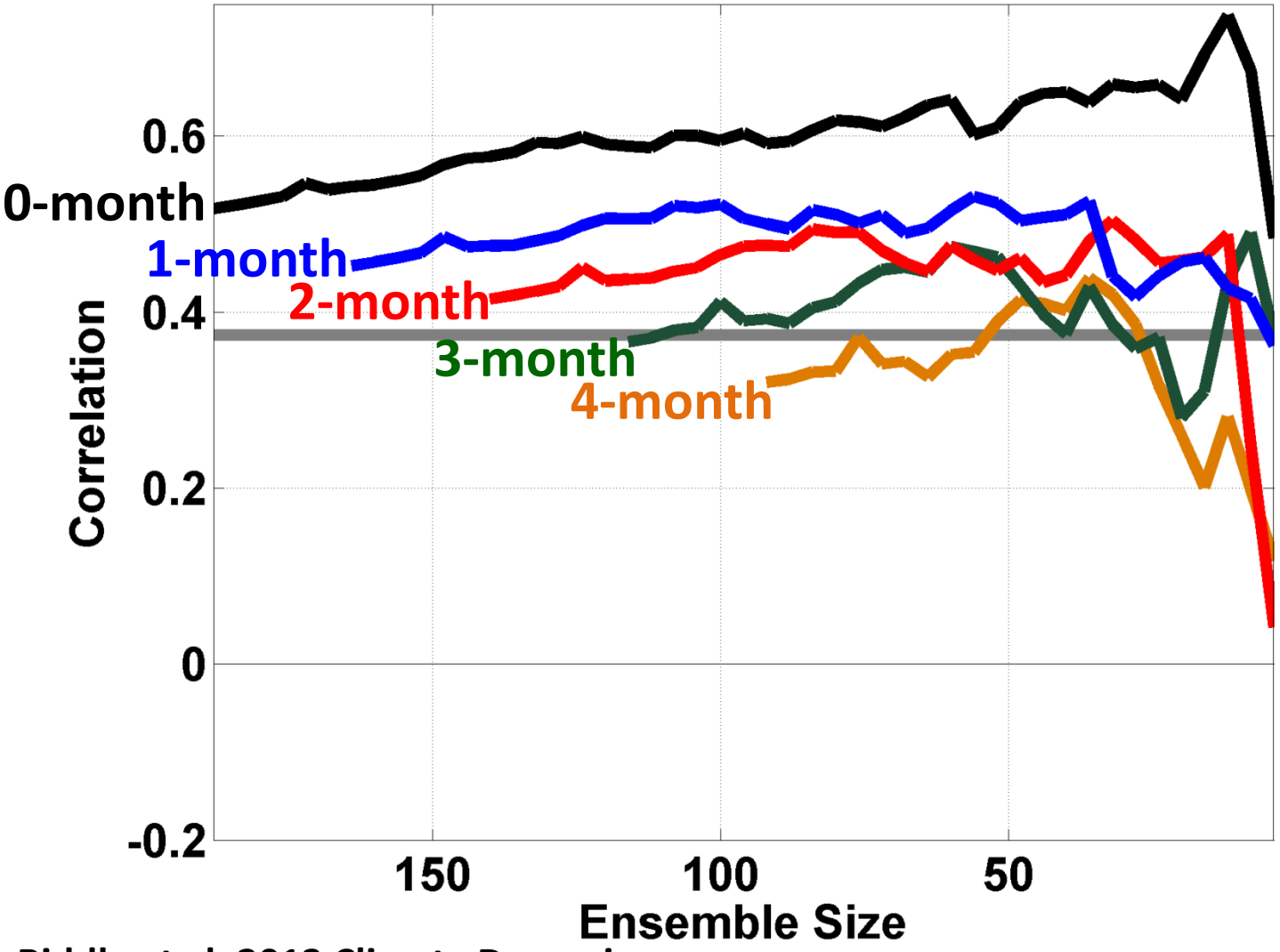
64-member average
16-member average
4-member average





Riddle et al, 2013 Climate Dynamics

Skill of CFSv2 forecasts of the DJF AO as a function of ensemble size



5% significance threshold

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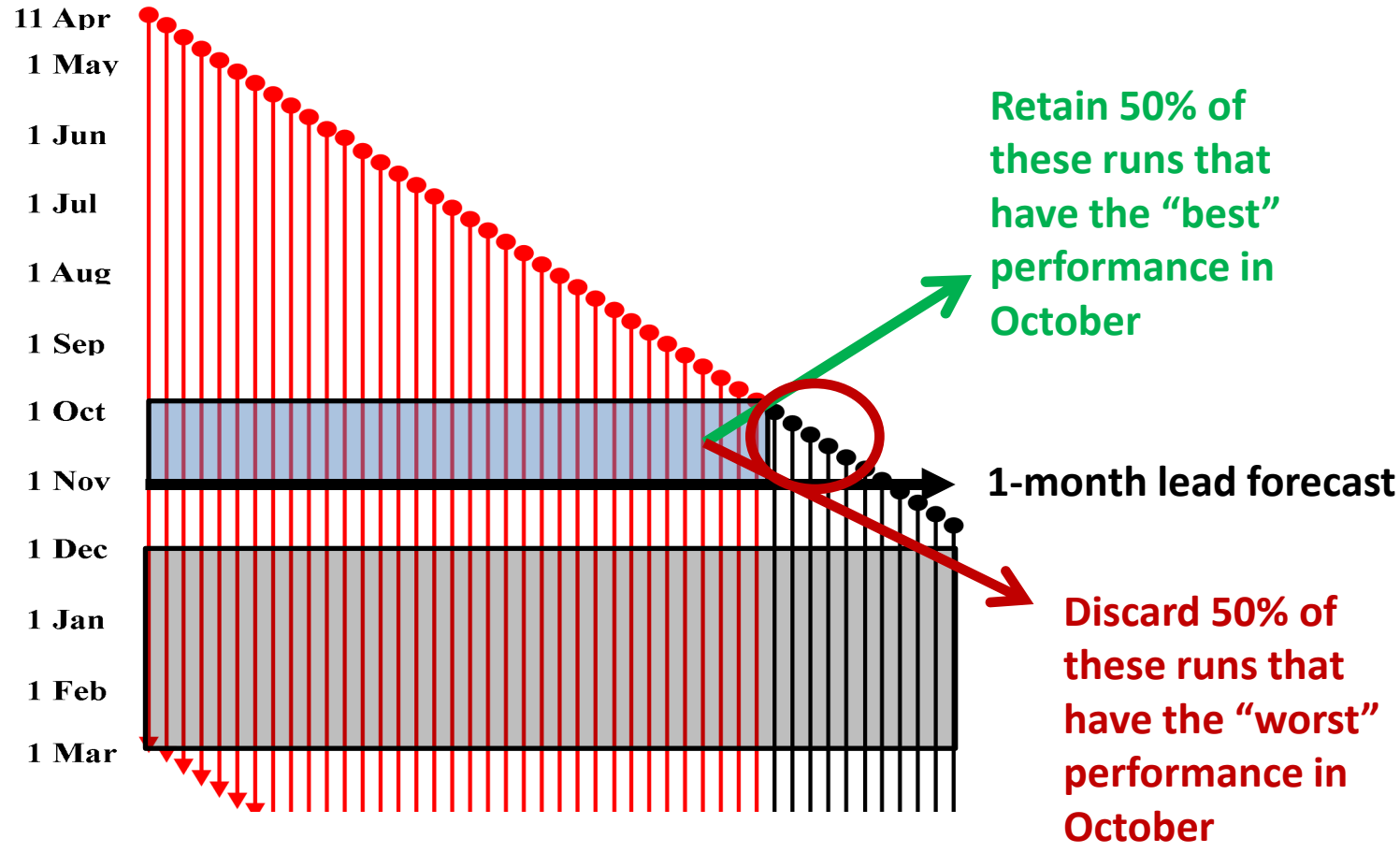
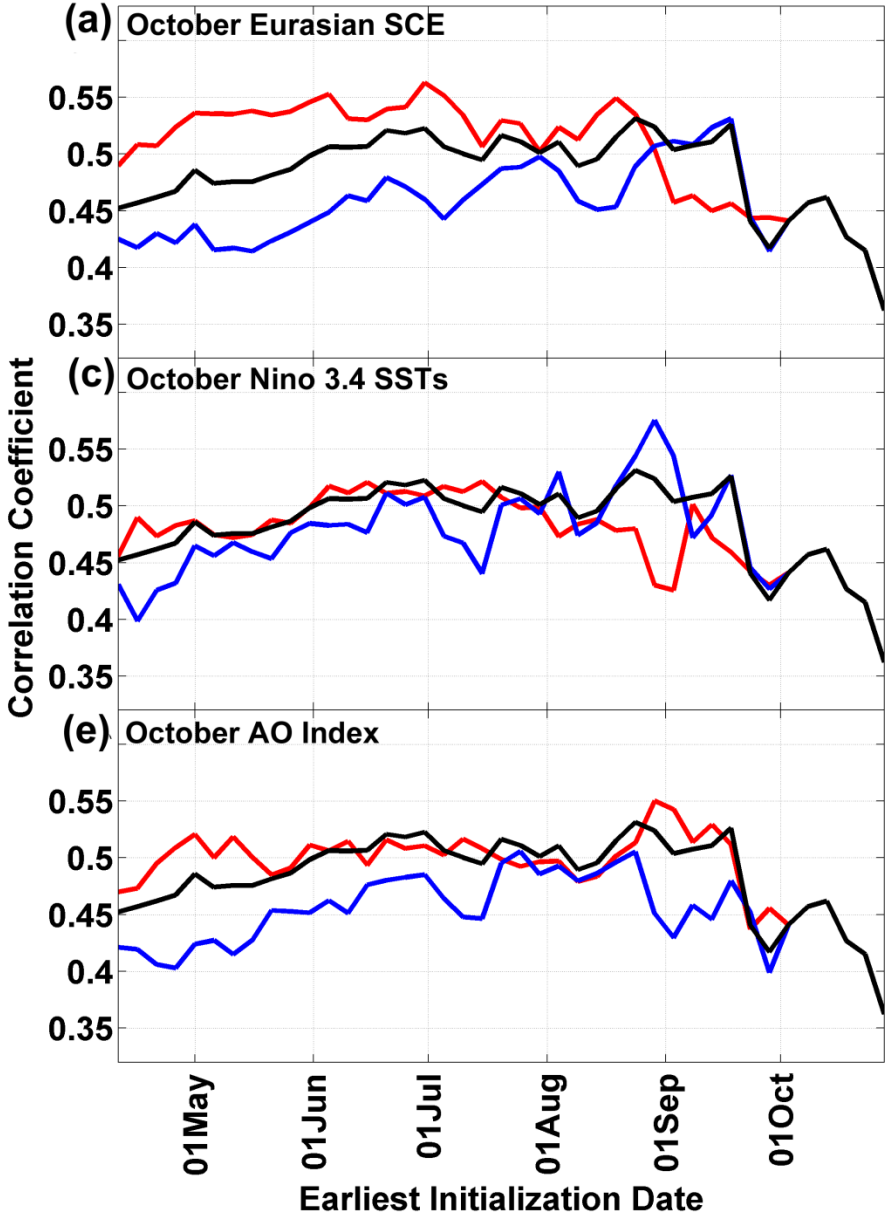
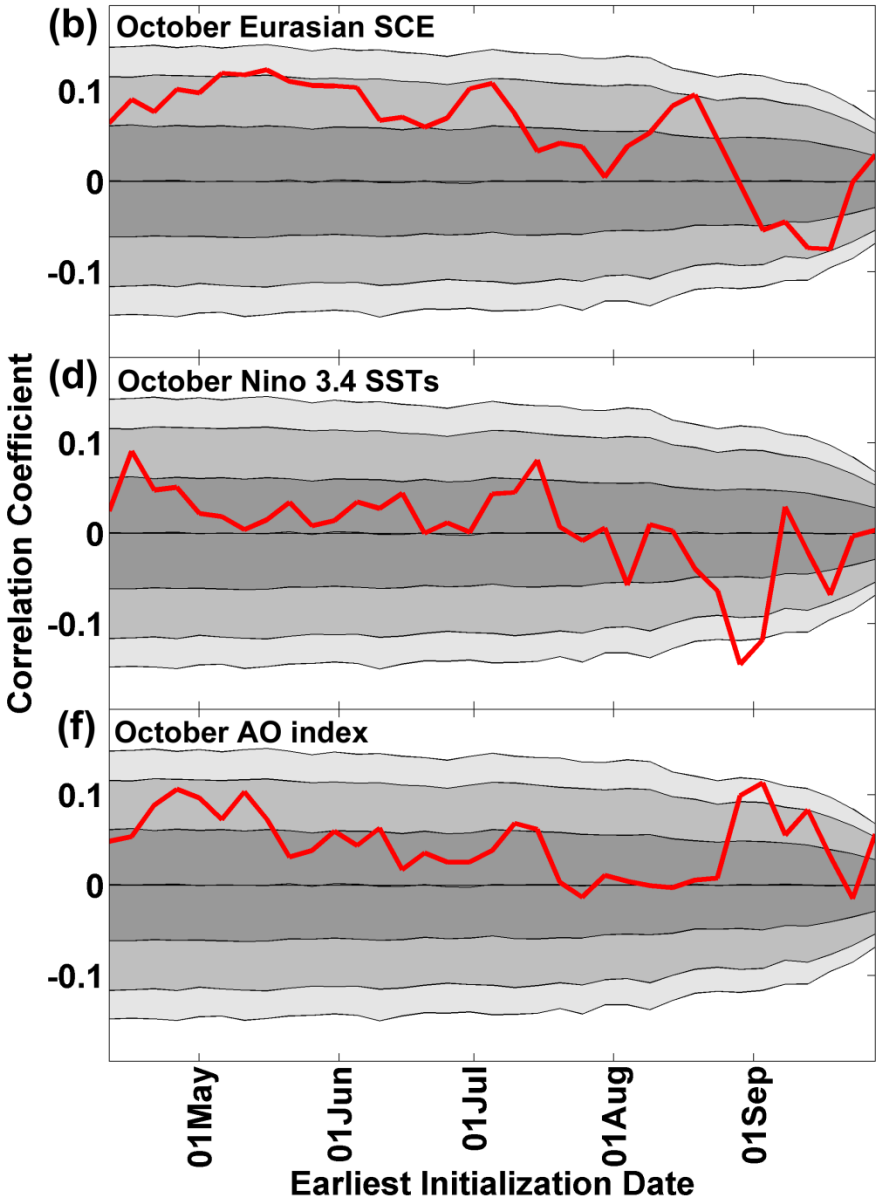
Can skill be improved by using a simplified version of “dynamic stratification”?



Dynamic stratification: 1-month lead forecast





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What might be causing this skill in the model?

Eurasian Snow cover?

More Eurasian snow in October precedes negative AO

Summer Arctic Sea Ice Extent?

Reduction in sea ice extent forces negative AO in some models

North Atlantic SSTs?

Warmer SSTs near Greenland with colder anomalies to the south can force negative AO in some models

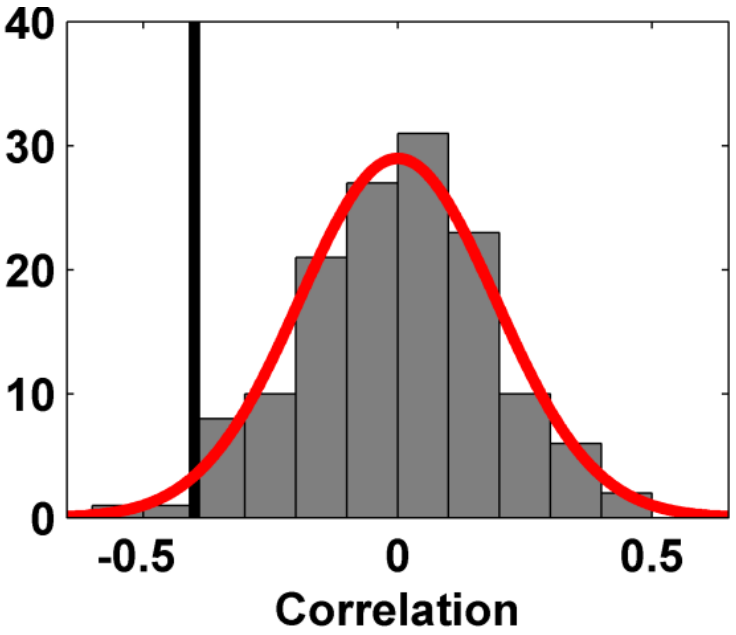
ENSO/Tropical SSTs?

Possible slight tendency towards negative AO during El Nino

Others? (QBO, Solar Activity, Dust, Aerosols, Ozone chemistry, etc.)

Oct Eurasian snow/DJF AO correlations in the Obs and in CFSv2

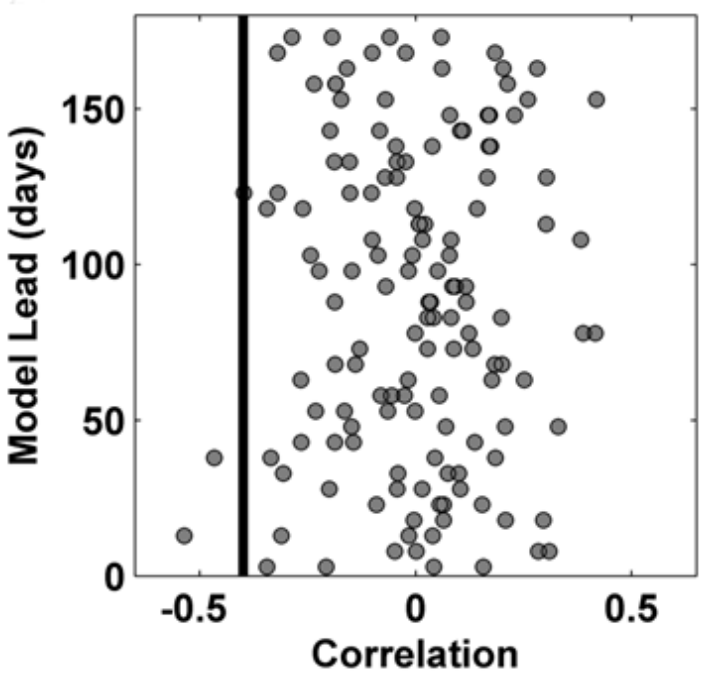
Observed Correlation



Grey: Histogram of correlation values internal to the model runs

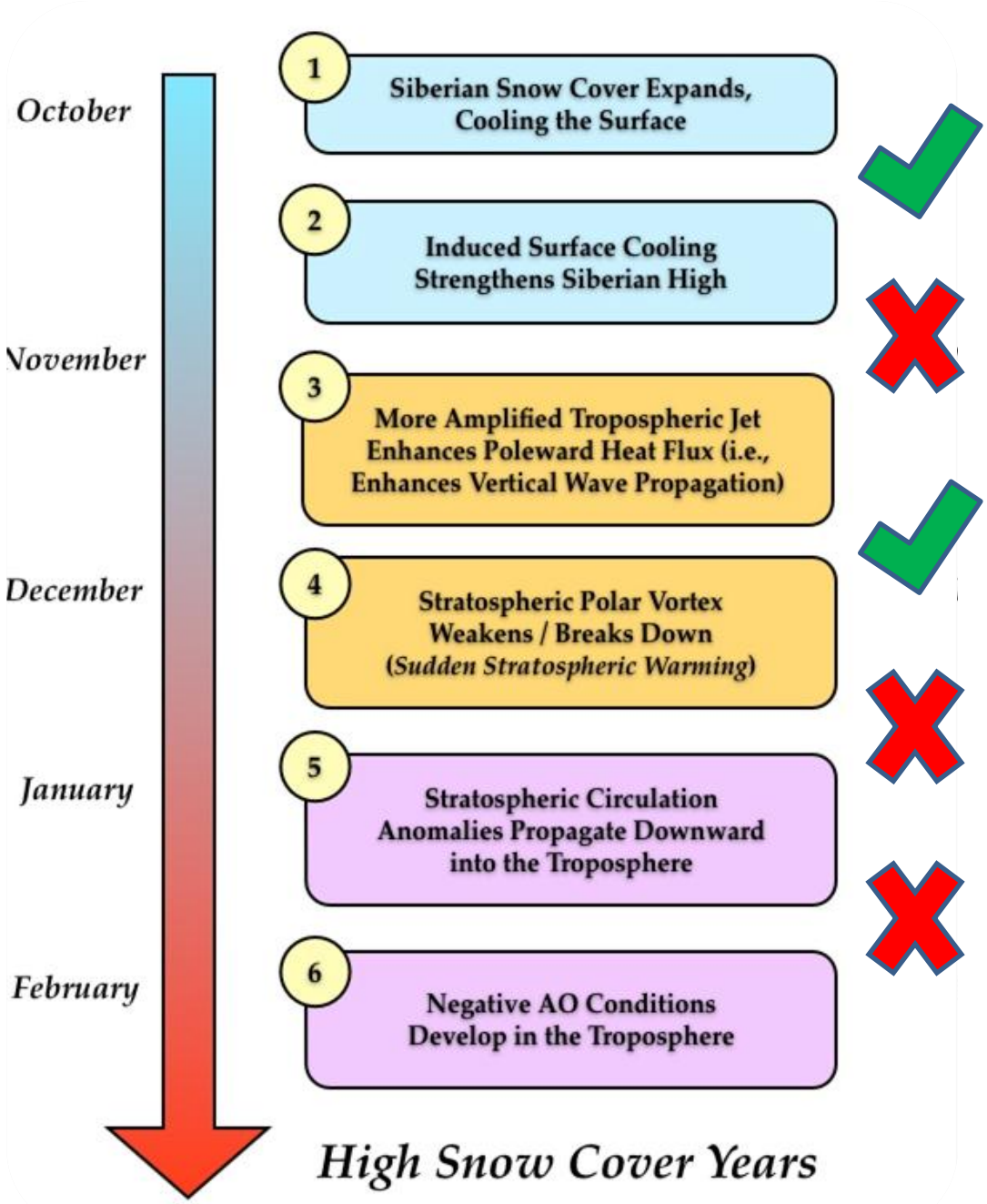
Red: Null distribution

Observed Correlation



Grey Dots: Correlation values as a function of model lead time

October Euraisan Snow extent -> DJF AO: Proposed mechanism



Conclusions

1) Lagged ensemble forecasts using CFSv2 have small but discernible skill in predicting wintertime AO index at lead-times up to 3 months, using a variety of ensemble sizes. By analyzing multiple lead times and ensembles, we provide more robust estimates of skill than previous studies.

2) A simplified dynamic stratification procedure was applied to the ensemble forecasts . Forecasts based on runs with a good representation of October Eurasian SCE, October Nino3.4 SSTs, and the October AO were all found to produce slightly better ensemble forecasts than runs with poor representation of these features. However, the differences were not statistically significant.

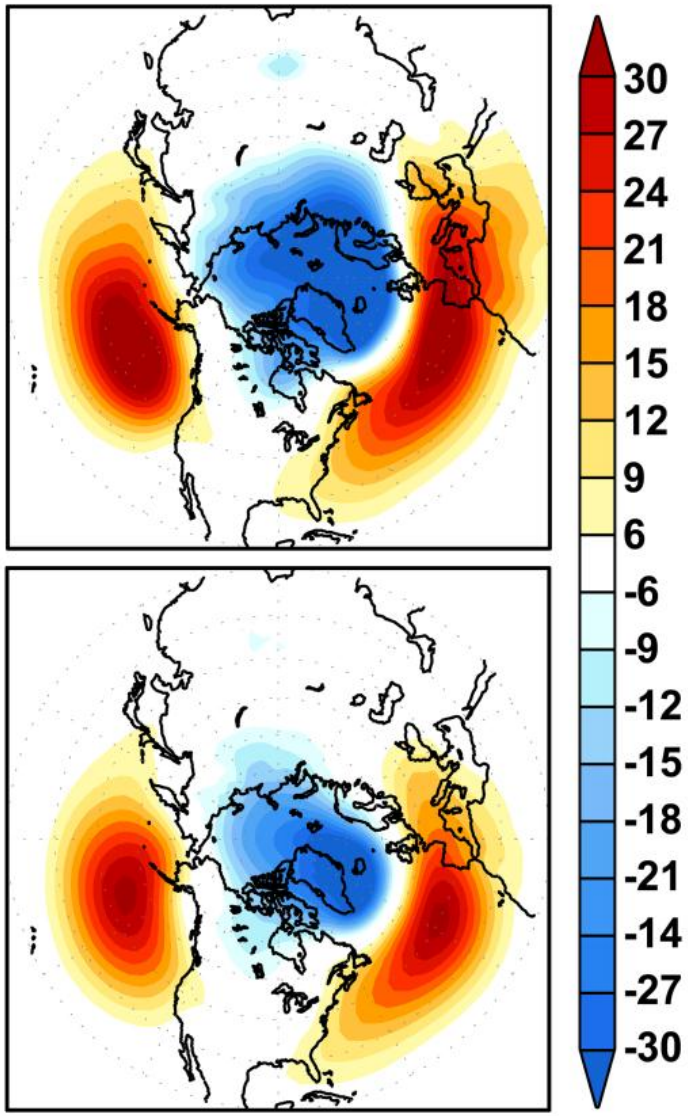
3) Further analysis suggested that individual CFSv2 runs do not capture key features and correlations linking October Eurasian snow cover to the wintertime.

4) Thus, further work is needed to understand what mechanisms are responsible for the skill in the model.

AO loading pattern in the hindcasts

CFSR

Average AO pattern in CFSv2 seasonal hindcast runs



Skill of CFSv2 forecasts of the DJF AO using as a function of ensemble size and forecast lead